

-7-

REMARKS

Claims 1-20 are pending.

In the Office Action, claims 1-20 are rejected under 35 U.S.C. § 102(b) as being anticipated by Lee, US 5,991,249 ("Lee '249"). This rejection is respectfully traversed.

Independent claims 1, 15 and 20 are directed to an optical encoder (or sensor head therefor) that employs a light source, a multi-track encoder scale, and separate optical detectors for detecting light that is reflected from the different tracks of the encoder scale. The encoder includes an optical wavefront dividing element that divides light from the source into multiple beams which are directed to the respective tracks and thence to the respective detectors. As described in the application, this configuration provides several important benefits especially when the light source emits a narrow cone of light, such as is the case with vertical cavity surface emitting lasers (VCSELs). In the claimed encoder, it is possible to have close spacing between the light source/detector substrate while directing sufficient light to each detector to enable robust operation, and furthermore doing so efficiently so that VCSEL power is not wasted illuminating an overly broad area. These benefits are achieved using the optical wavefront dividing element that divides the light into separate beams that are specifically directed to the different tracks and detectors. In the absence of the optical wavefront dividing element, proper operation of the multi-track encoder would be enabled only by less desirable alternatives, such as by increasing the spacing between the light source/detector substrate and the scale and/or increasing the VCSEL power substantially.

An example of the claimed encoder/sensor head is shown in Figure 3 of the application. The wavefront divider 350 splits an incident beam 103 into two beams 105a and 105b and directs them to two different tracks, one the main grating track 162 and the other an index element 166 of an index track. The reflected beams are directed back to respective detectors 140 and 120.

Lee '249 shows two substantially different arrangements for sensing optical tracks in a floppy disk drive. Figure 1 shows a prior art approach that involves a lens 13 used to split light from a source 11 into two beams, one directed to a floppy disk 15 and another to an encoder 16 which is a strip of optical tracks along the inside housing of the floppy disk drive. These beams are apparently sensed by separate elements of a multiple-element detector 18. In an entirely separate arrangement shown in Figure 2 of Lee '249, a header 104 is placed directly opposite a medium 107 on which optically readable circular tracks are engraved, with no intervening optical elements such as lenses etc. The header includes a light source 102 and a detector 103. The light source generates a diverging beam of light 105 that is reflected from the tracks of the medium 107 to the detector 103.

Lee '249 is not seen to be aware of the problem of narrow cones of light from VCSEL sources. In the schematic diagram of Figure 2, it appears to be assumed that the light beam 105 is sufficiently divergent to illuminate the entire detector 103. Lee '249 does not describe how this is accomplished. And in any event it certainly is not accomplished through the use of any intervening optical element such as a wavefront dividing element – it is an explicit teaching of Lee '249 to avoid the use of optical components between the source/detector and the scale (See col. 2 lines 18-24, col. 5 lines 44-45 for example).

The Office Action on page 2 incorrectly describes Lee '249 as teaching a combination of elements as set forth in claim 1. This section refers to elements of Lee '249 from both the arrangement of Figure 1, such as the diffractive optical element 12, and from the entirely separate arrangement of Figures 2 et seq. However, these two arrangements essentially have nothing to do with each other – Figure 1 is described as a prior art arrangement which exhibits a certain problem, and Figures 2 et seq. are the disclosed inventive solution.

More specifically, the diffractive optical element 12 of Figure 1 in Lee '249 is specific to the sensor of Figure 1 and not at all pertinent to a sensor like that of Figure 2. The diffractive element 12 directs one light beam to a scale on a floppy

disk that is above the sensor and directs another beam to a scale on a housing that appears to be below the sensor. There is no analogous function performed in the arrangement of Figures 2 et seq. In Figures 2 et seq., Lee '249 shows an encoder that entirely dispenses with any optical element between the source/detector and the scale tracks. There is no plurality of light beams, but only a single beam (with an incident portion 105 and a reflected portion 106) that is diverging as it travels from the source to the reflective medium 107 and then to the detectors.

There is an additional important, albeit subtle, aspect of Lee '249 that is relevant to the present rejection. The tracks 304 in Lee '249 are servo tracks, which are used to maintain correct radial position of a read/write head with respect to the medium 107. The positional parameter of interest in Lee '249 is the radial position of the head that is carrying the optical sensor. Lee's detector elements 404 and 405 are disposed across the tracks 304, such that their long axes extend in the radial direction, and the interference pattern that is detected is a radially-varying pattern created from a plurality of neighboring tracks 304 of different radii that are illuminated by a single coherent light beam 305. Thus, although Lee '249 shows multiple "tracks" 304 in the sense of "concentric circular marks", it is actually the case that it is the collection of the tracks 304 that forms one optically readable scale (diffraction grating) that provides radial position information. Thus, in a more accurate sense, the entire collection of the circular marks 304 in Lee '249 creates but one optically readable "track" that provides radial position information. This understanding of Lee '249 is pertinent for the following reason - there are clearly not multiple beams directed to different ones of the circular marks 304 in the arrangement of Figure 2, and any such arrangement would make no sense. There is but one scale or diffraction grating which is formed by the collection of tracks 304, and this scale receives a single light beam 305 and reflectively diffracts the light to create a single interference pattern that is sensed by an optical detector to derive radial position information.

-10-

Based on the above understanding of Lee '249, it should be clear that none of the independent claims 1, 15 and 20 of the present application is either anticipated or rendered obvious by this reference. These claims are directed to an optical encoder/sensor head having an optical wavefront divider that directs plural beams to respective tracks of a reflective, multi-track encoder scale that is disposed opposite the sensor head. In Figure 1 of Lee '249, there is no single multi-track encoder scale, but rather a floppy disk and a disk drive housing both arranged perpendicular to the detectors rather than opposite them. Figures 2 et seq. of Lee '249 do not include any optical elements between the source/detector substrate and the medium (and emphatically so), and do not employ multiple beams of light directed to multiple tracks of an encoder scale. Moreover, there is no teaching or suggestion to in any way combine these two separate arrangements of Lee '249, and in fact any use of an optical element in the arrangement of Figures 2 et seq. is explicitly discouraged. Thus, Lee '249 neither anticipates nor renders obvious the subject matter of these claims, and therefore these claims are allowable notwithstanding the teaching of Lee '249.

The remaining claims incorporate, either directly or indirectly, the features of claim 1 discussed above, and therefore these claims are allowable in view of Lee '249 for at least the same reasons.

Additionally, at least some of the dependent claims recite additional features not seen to be taught or suggested by Lee '249, notwithstanding the contrary assertions in the Office Action. For example, Lee '249 is not seen to show the arrangement of claim 4 having two detectors on opposite sides of a source. Figure 4 of Lee '249, which is referred to in the Office Action, clearly shows all detector elements (e.g. elements 404, 405) located to the right of the source 401. With respect to the specific grating profiles for the wavefront dividing element of claims 7-9, there is no description whatsoever of any specific grating profile for the diffractive element 12 of Lee '249 which the Office Action has alleged to be the equivalent of the claimed wavefront dividing element. Moreover, the Office Action erroneously refers to Figures 4-6 of Lee '249, which

-11-

describe alternative sets of detector elements and different masks that can be placed thereon - these have nothing to do with any wavefront dividing element. Thus these claims recite subject matter that even further distinguishes them from Lee '249.

Claims 1-20 have also been rejected under 35 U.S.C. § 102(b) as being anticipated by Lee et al., US Published Application 2003/0010906 (hereinafter "Lee '906"). This rejection is respectfully traversed.

Lee '906 differs from Lee '249 in two material respects. Lee '906 omits the description of optical encoders to control read/write head positioning in conjunction with disk drive servo tracks. Additionally, Lee '906 includes in Figure 5 a description of an optical encoder with allegedly improved light collection. The following is the description of Figure 5 in Lee '906:

[0061] In FIG. 3 the light beam reflected back from the medium diverges towards the detector. The area of the light sensitive element on the detector is smaller than the beam on the detector. Therefore, the detector can only collect a relatively small amount of the reflected light. FIG. 5 shows a second preferred embodiment of the present invention, which can improve the light collection of the first embodiment shown in FIG. 3. A laser chip 501 is shown mounted on a detector chip 502. Laser beam 503 from chip 501 is incident on a diffractive cylindrical lens 504. The top view of the grating of diffractive cylindrical lens 504 is shown in FIG. 5(b). The cylindrical lens 504 is different from a spherical lens in that it has focal power only in one dimension. The phase variation on such a diffractive element has the form

(equation omitted)

[0062] where A is the wavelength of the laser and F is the focal length. Due to the diffractive cylindrical lens, beam 503 is focused to a line perpendicular to the plane of the paper on the grating surface 505 of the moving medium. The diverging beam in the direction normal to the plane of the drawing still interacts with the grating to project an interference pattern on the detector. The reflected beam from surface 505 passes through a periodic grating 506 whose function is to spread the light beam more uniformly across the detector 507. The light detecting element 507 is similar to the detector shown in FIG. 3(b) or FIG. 3(c).

-12-

Contrary to the assertions in the Office Action, the diffractive cylindrical lens 504 of Lee does not divide an incident light beam into a plurality of diffracted light beams directed toward respective tracks of an encoder scale. Rather, the lens 504 focuses the beam 503 to one line interference pattern which interacts with a single grating on the grating surface 505 and reflected back to a single detector 507. It is further noted that the Office Action erroneously characterizes the beams 305 and 306 of Figure 3(a) as a plurality of beams resulting from dividing an incident beam. The beam 305 is a single diverging cone of light emerging from the source 302, and the beam 306 is a single beam that is reflected from the medium 307. Additionally, the Office Action misleadingly discusses the embodiments of Figures 3(a) and 5(a) of Lee simultaneously, as though there is some suggested combination of them. In fact, they are quite distinct as should be clear from the above description of Figure 5(a). Figure 3(a) exhibits the problem that Figure 5(a) is intended to address, and the configuration of Figure 5(a) is presented as an alternative to that of Figure 3(a). Thus, there is no suggestion in Lee '906 of some hypothetical combination of Figures 3(a) and 5(a) on which claim 1 of this application can be read.

For the foregoing reasons, it is respectfully submitted that Lee '906 does not teach or suggest the subject matter of claim 1, and therefore claim 1 is patentable notwithstanding the teaching of Lee '906. Reconsideration and withdrawal of the rejection based on this reference are respectfully requested.

The remaining claims incorporate, either directly or indirectly, the features of claim 1 discussed above, and therefore these claims are allowable in view of Lee '906 for at least the same reasons. It is further noted that the above-noted shortcomings of Lee '249 are also shortcomings of Lee '906, and therefore the above-discussed dependent claims are even further distinguished from Lee '906 in the same manner as discussed above.

-13-

New Claims

New claims 21 and 22 have been added. These recite subject matter that is not seen to be shown in the applied references, and therefore these claims are believed to be allowable. These claims are supported by the application as filed, for example Figure 1 and related description, and equation (4) and related description. No new matter has been added. Favorable consideration of these claims is respectfully requested

If the U.S. Patent and Trademark Office deems a fee necessary, this fee may be charged to the account of the undersigned, Deposit Account No. 50-0901.

If the enclosed papers or fees are considered incomplete, the Patent Office is respectfully requested to contact the undersigned collect at (508) 366-9600, in Westborough, Massachusetts.

Respectfully submitted,



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